

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of)	
)	
Update to Parts 2 and 25 Concerning Non-)	IB Docket No. 16-408
Geostationary, Fixed-Satellite Service Systems)	
and Related Matters)	

To: The Commission

REPLY COMMENTS OF THE BOEING COMPANY

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SUMMARY

The Boeing Company (“Boeing”) provides these reply comments to address the current need to reduce unnecessary regulatory barriers to facilitate the launch and operation of a new generation of non-geostationary satellite orbit (“NGSO”) systems operating in the fixed-satellite service (“FSS”) in order to provide very high data rate broadband services to consumers throughout the United States and on a global basis. To facilitate the anticipated growth in broadband services provided by NGSO FSS systems, the regulatory environment must be more accommodating to NGSO FSS operations, while continuing to ensure adequate protections for current operations and future growth of geostationary satellite orbit (“GSO”) FSS networks. Specifically, the Commission should consider the following:

- The Commission should refrain from making any significant changes to its rules governing the protection of GSO FSS networks by NGSO FSS systems until additional NGSO FSS systems have been launched and more is learned about their operational characteristics. Based on those actual operating characteristics, the Commission may then be able to relax significantly its protection requirements while still protecting GSO FSS networks pursuant to the criteria that was agreed upon in ITU-R Recommendation S.1323-2.
- The Commission should permit FCC earth stations to operate in the 17.8-18.3 GHz band on a secondary basis and relax the licensing requirements applicable to such earth stations by authorizing them on a blanket-licensed basis.
- The Commission should authorize NGSO FSS systems to operate on a secondary basis in the 18.3-18.6 GHz and 19.7-20.2 GHz bands employing existing ITU limits to protect GSO FSS systems.
- The Commission should authorize GSO FSS networks to operate in the 18.8-19.3 GHz band, but only on a secondary basis to ensure that these frequencies remain primarily available for use by NGSO FSS systems.
- The Commission should authorize FSS systems to operate in the 19.3-19.4 GHz, 19.6-19.7 GHz, and 29.3-29.5 GHz bands, but the Commission should consider giving NGSO FSS systems priority over GSO FSS systems in these frequencies.
- The Commission should extend the ITU’s existing PFD limits for NGSO FSS systems to the 17.8-18.6 GHz and 18.8-19.7 GHz bands. The Commission,

however, should not adopt an aggregate PFD limit of $-115 \text{ (dBW/m}^2\text{)}/\text{MHz}$ because such a restriction would impair the growth of innovative NGSO FSS systems.

- The Commission should incorporate into its rules the EPFD limits that exist in Article 22 for NGSO FSS systems operating in the Ka-band, but the Commission should refrain from imposing on NGSO FSS systems in the Ka-band all of its demonstration requirements (particularly the operational requirements) that it adopted for NGSO FSS systems in the Ku-band.
- The Commission should eliminate Section 25.156(d)(5) of its rules, but the Commission should not replace it with a presumption that NGSO FSS systems must protect GSO FSS networks in every frequency band where NGSO FSS systems have not been expressly provided priority in the Commission's rules.
- The Commission should expand its in-line avoidance rule to additional spectrum bands. The Commission should also refrain from making changes to its in-line avoidance rule and should not defer the issue of spectrum sharing between co-frequency NGSO FSS systems to the ITU process.
- The Commission should permit NGSO FSS system operators to decide for themselves how to share ephemeris data with operators of other systems. No evidence exists of a problem with the sharing of such data that would necessitate Commission regulation.
- The Commission should not risk the growth and development of new and innovating NGSO FSS systems either by adopting uplink off-axes EIRP density limits for earth stations operating with NGSO FSS systems, or by adopting NGSO system downlink power limits or Earth station gain criteria.
- The Commission should inject substantial flexibility into its milestone rules for NGSO FSS systems by allowing operators of such systems to designate their own thresholds for the number of satellites that reasonably constitutes the initial constellation that should be launched by the sixth year milestone, and subsequent thresholds for any later milestones. Granting such flexibility will not undermine the Commission's underlying goal of ensuring that spectrum resources are not left fallow.
- The Commission should eliminate its international geographic coverage requirement for NGSO FSS systems in order to give system operators additional flexibility to deploy different types of constellations that are optimized for different target customer groups.

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**REPLY COMMENTS OF
THE BOEING COMPANY**

The Boeing Company (“Boeing”) provides these reply comments in response to the Commission’s Notice of Proposed Rulemaking (“*NPRM*”) examining rules and policies governing the operation of non-geostationary satellite orbit (“NGSO”) systems operating in the fixed-satellite service (“FSS”).¹

Between the deadlines for comments and reply comments in this proceeding, the satellite industry held its largest annual conference at the Washington Convention Center. Evident during the conference was a fundamental shift in the way the satellite industry views its future. Once almost exclusively reliant on the use of spacecraft in geostationary satellite orbit (“GSO”), the satellite industry is now recognizing that its future growth depends on a combination of spacecraft in both GSO and NGSO configurations. Further, the satellite industry is looking to higher frequency bands, such as the V-band, to accommodate new systems that can provide very high data rate communications services to large populations wherever they reside.

¹ See Update to Parts 2 and 25 Concerning Non-Geostationary, Fixed-Satellite Service Systems and Related Matters, IB Docket No 16-408, *Notice of Proposed Rulemaking*, FCC 16-170 (Dec. 15, 2016) (“*NPRM*”).

To facilitate this growth, the regulatory environment must be more accommodating to NGSO FSS systems. While GSO FSS networks must certainly continue to be protected, the Commission's rules should be revised to reflect a more balanced and less burdensome approach to spectrum sharing. The need for this balance is reflected in the vast majority of the comments that were filed in response to the Commission's *NPRM*, including by operators of very large GSO fleets. Boeing therefore urges the Commission to use this proceeding to initiate a framework for a better regulatory environment for the launch and operation of NGSO FSS systems.

I. THE COMMISSION SHOULD REFRAIN FROM MAKING SIGNIFICANT CHANGES TO ITS RULES FOR SHARING BETWEEN NGSO AND GSO FSS SYSTEMS UNTIL ADDITIONAL NGSO FSS SYSTEMS ARE OPERATING

An important issue that is relevant to a number of the proposals raised by the *NPRM* is the current rules to ensure that NGSO FSS systems adequately protect GSO FSS networks in spectrum bands where the latter have priority. For example, paragraphs 9, 10, 16, and 18-20 of the *NPRM* directly address this issue.

Boeing recognizes that the current rules of the FCC and the International Telecommunication Union ("ITU") governing the protection of GSO FSS networks by NGSO FSS systems were developed almost twenty years ago based on a prior generation of NGSO FSS systems. Many of today's proposed NGSO FSS systems involve much larger constellations. Accompanying these larger constellations, however, is the use of much narrower, often steerable transmit and receive beams that are far more capable of discriminating in their communications. Many of the new NGSO FSS systems also employ satellite transmit and receive beams that are reconfigurable in orbit, enabling dynamic adjustments to power and coverage. Operators of

NGSO FSS systems will therefore be able to respond to changing conditions in real time, such as accommodating the launch of additional NGSO FSS constellations using the same spectrum.

Operators of the next generation of NGSO FSS systems will not only have the technical capability to dynamically protect GSO FSS networks, they will also have a substantial economic incentive to do so. Many of the companies currently seeking Commission authority to launch NGSO FSS systems are also the global leaders in the operation of GSO FSS networks, including Intelsat (through WorldVu), SES (through O3b), Telesat, and ViaSat. It is inconceivable that any of these four companies would propose to operate NGSO FSS networks that could place at risk the safe and effective operation of their sizable GSO satellite fleets.

Boeing is similarly situated, maintaining both its legacy and its future growth on its role as the market leader in the design and manufacture of GSO spacecraft. Major satellite operators currently rely on more than two dozen Boeing 702 satellites and Boeing has about one dozen more 702 spacecraft in production. Thus, although Boeing believes that NGSO FSS satellites will play an increasingly important role in the future of the satellite communications industry, the critical role of GSO satellites for the mass distribution, broadcast, and backhaul of critically important communications services will only continue to increase.

Therefore, the Commission should not attempt to repeat the exhaustive (and ultimately needless) efforts of the WRC-2000 and WRC-03 study cycles by trying to draft new rules that attempt to anticipate every sharing condition that could exist between various types of NGSO FSS systems and GSO networks. The satellite industry and the Commission would be far better served by reaffirming the foundational agreement that formed the basis for the current protection rules for NGSO/GSO sharing. Specifically, ITU-R Recommendation S.1323-2 remains the standard for how much interference can be caused by NGSO FSS networks (both individually

and in the aggregate) to GSO FSS networks.² Rather than attempt to revise its protection regulations based on speculation regarding the characteristics of the next generation of NGSO FSS networks, the Commission should affirm that, whatever its rules currently require, NGSO FSS systems authorized to operate in the United States will be required to comply with the S.1323-2 criteria, both individually and in the aggregate.

Commission reliance on ITU-R Recommendation S.1323-2 would *not* result in regulatory uncertainty for prospective NGSO FSS system operators. First, as noted above, most modern NGSO FSS systems are capable of reconfiguring their operations in orbit, including making adjustments to ensure that the S.1323-2 protection criteria are satisfied. Second, once additional NGSO FSS systems have been launched, Boeing anticipates that it will become apparent that the existing protection rules greatly exceed what is needed to ensure adherence to the S.1323-2 protection criteria, creating an opportunity to relax the limits based on the actual operational characteristics of the NGSO FSS systems in existence at that time. Such changes to the rules of the ITU and the FCC could then be implemented in a manner that would benefit all participants and end users of the satellite communications industry.

² The ITU-R reached agreement that aggregate NGSO FSS transmissions not be responsible for more than 10 percent of the amount of time for which the link $C/(N+I)$ ratio for a GSO satellite link is permitted to fall below the shortest-term performance threshold defined for the considered link. See Section 3.1.2.1.2 (b) of the CPM Report to WRC-2000; *see also* ITU-R Recommendation S.1323-2, “Maximum Permissible Levels of Interference in a Satellite Network (GSO/FSS; NON-GSO/FSS; NON-GSO/MSS Feeder Links) in the Fixed-Satellite Service Caused by other Co-directional Networks below 30 GHz.”

II. MOST COMMENTERS OBSERVED THAT FSS EARTH STATIONS SHOULD BE PERMITTED TO USE THE 17.8-18.3 GHZ BAND ON A SECONDARY, BLANKET-LICENSED BASIS

The commenting parties seem uniform in supporting the Commission's proposal³ to permit the operation of FSS earth stations in the 17.8-18.3 GHz band on a secondary basis.⁴ A number of these parties took the additional step of questioning the need to limit such earth stations to individually-licensed facilities, explaining that a blanket-licensed approach to satellite earth stations is fully warranted.⁵ As OneWeb explains, authorizing only individually-licensed earth stations "is overly restrictive, since operations of FSS earth stations in the presence of terrestrial stations in these frequency bands will be possible even with a larger number of NGSO user terminals deployed."⁶ ViaSat expresses the same view, explaining "the nature and number of earth stations passively receiving satellite signals does not present any risk to terrestrial services in this context."⁷

LeoSat provides an additional reason to authorize earth stations on a secondary, blanket-licensed basis, explaining "[t]his approach is consistent with the approach taken in Europe, which has permitted coordinated FSS receive earth stations as well as uncoordinated and unprotected FSS receive earth stations in satellite downlink bands shared with FS in the 17.7-

³ See *NPRM*, ¶ 9.

⁴ See *SLA Comments* at 4-5, *Boeing Comments* at 2, *SpaceX Comments* at 4, *ViaSat Comments* at 8, *OneWeb Comments* at 29-31, *SES/O3b Comments* at 10-11, *LeoSat Comments* at 4, *Space Norway Comments* at 2, *Lockheed Comments* at 2, *Telesat Comments* at 4, *ViaSat Comments* at 7.

⁵ See *Boeing Comments* at 3-4, *ViaSat Comments* at 8, *OneWeb Comments* at 31-32, *SES/O3b Comments* at 11-12, *LeoSat Comments* at 4, *Inmarsat Comments* at 3, *ViaSat Comments* at 7-8, *Space Norway Comments* at 2.

⁶ *OneWeb Comments* at 31.

⁷ *ViaSat Comments* at 8.

19.7 GHz frequency band since 2000.”⁸ Therefore, the Commission should refrain from employing an excessive regulatory approach to satellite earth station operations in the 17.8-18.3 GHz band and instead allow them to operate on a secondary basis using a blanket-license approach.

III. THE COMMISSION SHOULD AUTHORIZE SECONDARY NGSO FSS OPERATIONS IN THE 18.3-18.6 GHZ AND 19.7-20.2 GHZ BANDS

The vast majority of parties commenting on this issue⁹ expressed support for the operation of NGSO FSS systems in the 18.3-18.6 GHz and 19.7-20.2 GHz bands.¹⁰ Although ViaSat did not oppose such secondary operations, it urged a wholesale reexamination of the detailed protection criteria that was developed to ensure that NGSO FSS operations do not cause unacceptable levels of interference to GSO FSS networks.¹¹ As discussed above in Section I of these reply comments, it is premature to attempt to revisit the ITU or FCC protection limits for NGSO FSS systems operating in bands shared with GSO FSS networks. The Commission should instead retain the existing limits with the express caveat that the Commission’s rules will eventually be adjusted to better align with the protection criteria specified by ITU-R Recommendation S.1323-2. Further, the Commission should allow NGSO FSS systems to operate on a secondary basis in the 18.3-18.6 GHz and 19.7-20.2 GHz bands.

⁸ *LeoSat Comments* at 5 (citing European Radiocommunications Committee Decision on the shared use of the band 17.7-19.7 GHz by the fixed service and Earth stations of the fixed-satellite service (space-to-Earth), ERC/DEC/(00)07 (Oct. 19, 2000, amended Mar. 4, 2016)).

⁹ See *NPRM*, ¶ 10.

¹⁰ See *SIA Comments* at 5, *Boeing Comments* at 4-5, *SpaceX Comments* at 5, *OneWeb Comments* at 16-19, *SES/O3b Comments* at 13, *LeoSat Comments* at 6, *Inmarsat Comments* at 4, *Space Norway Comments* at 3, *Lockheed Comments* at 2, *Telesat Comments* at 16.

¹¹ See *ViaSat Comments* at 11-18.

IV. THE COMMISSION SHOULD LIMIT BOTH THE OPERATION AND REGULATORY STATUS OF GSO FSS NETWORKS TO AN UNPROTECTED, NON-INTERFERENCE BASIS IN THE 18.8-19.3 GHZ BAND

All parties seem to agree that GSO FSS networks should be permitted to operate in the 18.8-19.3 GHz band on some basis.¹² The vast majority of those parties concur with the Commission's initial proposal¹³ that GSO FSS networks be permitted to operate in the band on a secondary basis to NGSO FSS systems.¹⁴

Some parties argue that GSO FSS networks should be given co-primary status to NGSO FSS systems in the 18.8-19.3 GHz band in order to align with international rules.¹⁵ Echostar further argues that GSO FSS networks should be given co-primary status because NGSO FSS systems have not deployed sufficiently in the Ka-band.¹⁶ Echostar's argument, however, disregards the large number of NGSO FSS systems that have recently been proposed in the Ka-band. Further, as OneWeb argues, if GSO FSS networks are elevated to co-primary status in the 18.8-19.3 GHz band, then the application of the existing EPFD limits in adjacent bands would effectively relegate NGSO FSS systems to secondary status.¹⁷

¹² See, e.g., *SLA Comments* at 6.

¹³ See *NPRM*, ¶ 11.

¹⁴ See *Boeing Comments* at 5, *SpaceX Comments* at 5, *SES/O3b Comments* at 13, *Space Norway Comments* at 3.

¹⁵ See *Inmarsat Comments* at 4-5, *Intelsat Comments* at 2-5, *Echostar Comments* at 3-4, *ViaSat Comments* at 8-9.

¹⁶ *Echostar Comments* at 4-7.

¹⁷ See *OneWeb Comments* at 16.

As the majority of commenters observe, there are currently very few frequency bands where NGSO FSS systems are not required to protect GSO FSS networks.¹⁸ NGSO FSS systems require access to frequencies in which they are not required to protect GSO FSS networks in order to ensure that they can provide adequate coverage, particularly in equatorial regions, which are already the most challenging locations to serve for NGSO FSS systems using polar orbit constellations. As Space Norway explained, “[t]he bands to which EPFD limits and RR Article 22 do not apply (including the 18.8-19.3 GHz and 28.6-29.1 GHz bands) give NGSO FSS operators more leeway in designing their systems, and in developing innovative service offerings, than in other bands.”¹⁹ The Commission also recognized this when it most recently updated its plan for the Ka-band, explaining

because the 18.8-19.3 and 28.6-29.1 GHz primary NGSO designations are the only bands that do not restrict NGSO systems from pointing at the orbit, this fact greatly increases the capacity of satellites in this band, since fewer satellites will be required if a larger part of the sky is available for service. To avoid pointing at the [geostationary] orbit would require more satellites to achieve the same system capacity, increasing the cost of providing NGSO/FSS services at the same level.²⁰

Although NGSO FSS system technology has improved tremendously since the Commission made these observations, the Commission’s conclusions are as true today as they were in 2000. Therefore, although the Commission should permit GSO FSS networks in the 18.8-19.3 GHz band, it should do so solely on a secondary basis to NGSO FSS systems.

¹⁸ See *Boeing Comments* at 11, *SpaceX Comments* at 6, *OneWeb Comments* at 16, *SES/O3b Comments* at 13, *Space Norway Comments* at 4.

¹⁹ *Space Norway Comments* at 4.

²⁰ Redesignation of the 17.7-19.7 GHz Frequency Band, Blanket Licensing of Satellite Earth Stations in the 17.7-20.2 GHz and 27.5-30.0 GHz Frequency Bands, and the Allocation of Additional Spectrum in the 17.3-17.8 GHz and 24.75-25.25 GHz Frequency Bands for Broadcast Satellite-Service Use, *Report and Order*, 15 FCC Rcd 13430, ¶ 57 (2000)

V. THE COMMISSION SHOULD AUTHORIZE FSS IN THE 19.3-19.4 GHZ, 19.6-19.7 GHZ, AND 29.3-29.5 GHZ BANDS, BUT NGSO FSS SYSTEMS SHOULD HAVE PRIORITY OVER GSO FSS NETWORKS IN THESE FREQUENCIES

All commenters acknowledge that it would be appropriate and spectrally efficient to permit the operation of NGSO and GSO FSS systems in the 19.3-19.4 GHz, 19.6-19.7 GHz, and 29.3-29.5 GHz bands.²¹ Even Iridium acknowledges that the Commission's proposal is appropriate as long as Iridium's mobile-satellite service feeder links are adequately protected.²²

Boeing remains unclear, however, why NGSO FSS systems should be required to protect GSO FSS networks in these frequencies given that their current user is an NGSO system, namely Iridium. Granted, the international rules do not yet accommodate NGSO FSS operations in these frequencies,²³ but the Commission has on appropriate occasions sought to lead the international regulatory community by making frequency designations that, while inconsistent with international rules, are intended to set an example for the international community. At the very least, the Commission should consider the suggestion of Space Norway that NGSO FSS systems and GSO FSS networks be given equal status in this spectrum.²⁴ Such equal status, however, should not effectively require NGSO FSS systems to protect GSO FSS networks in these frequencies.

²¹ See *Boeing Comments* at 6, *SES/O3b Comments* at 14, *LeoSat Comments* at 6-7 (but only NGSOs), *Inmarsat Comments* at 5-6, *Intelsat Comments* at 2-3, *Space Norway Comments* at 4, *Lockheed Comments* at 2, *ViaSat Comments* at 9-10.

²² See *Iridium Comments* at 1-3.

²³ See *Inmarsat Comments* at 6 and 9.

²⁴ See *Space Norway Comments* at 4-5.

VI. THE COMMISSION SHOULD ADOPT POWER LIMITS FOR NGSO FSS SYSTEMS IN THE 17.8-18.6 GHZ AND 18.8-19.7 GHZ BANDS

Nearly every party that filed comments in this proceeding concurred with the Commission's proposal to extend the ITU's existing PFD limits for NGSO FSS systems to the 17.8-18.6 GHz and 18.8-19.7 GHz bands.²⁵ ViaSat argued that the existing ITU limits for NGSO FSS systems are likely no longer sufficient to protect GSO networks given the recent proposals for a new generation of NGSO FSS systems.²⁶ As Boeing noted in Section I of these comments, however, the current generation of NGSO FSS systems can be expected to include technical capabilities that will permit them to reconfigure their operations in orbit, both to respond to variations in customer requirements, and to facilitate sharing with GSO networks and other NGSO FSS systems. Therefore, rather than attempt to revise the existing rules for spectrum sharing between NGSO and GSO FSS systems, the Commission should reaffirm that NGSO FSS systems will be required to protect GSO FSS networks in these frequency bands pursuant to the protection criteria agreed upon in ITU-R Recommendation S.1323-2. The Commission and the satellite industry can then monitor the operation of new NGSO FSS systems as they are launched and make appropriate adjustments to the ITU limits (potentially either more or less restrictive) as conditions warrant.

Most parties commenting in this proceeding also urged the Commission to refrain from adopting an aggregate PFD limit of $-115 \text{ (dBW/m}^2\text{)/MHz}$.²⁷ Several parties noted that such a

²⁵ See *SIA Comments* at 7, *Boeing Comments* at 8, *SpaceX Comments* at 7, *OneWeb Comments* at 21, *SES/O3b Comments* at 18, *LeoSat Comments* at 8, *Inmarsat Comments* at 8, *Space Norway Comments* at 6, *Telesat Comments* at 6, *ViaSat Comments* at 10.

²⁶ See *ViaSat Comments* at 11-18.

²⁷ See *Boeing Comments* at 8-9, *SpaceX Comments* at 10, *OneWeb Comments* at 22, *SES/O3b Comments* at 19.

limit would excessively constrain NGSO FSS satellites operating at higher elevation angles where the gain of the victim terrestrial stations rolls off substantially in the direction of the NGSO satellite.²⁸ Boeing also explained that the adoption of a *de facto* limit on the aggregate PFD of a NGSO constellation will unnecessarily limit the broadband services and terminal sizes available from even a single NGSO FSS satellite and significantly constrain the design and/or performance of the entire constellation.²⁹

Instead, Boeing continues to believe that the Commission should use the more appropriate approach of performing EPFD analyses of the proposed NGSO constellations using reference NGSO receive terminals. Such EPFD analyses can incorporate multiple angles of arrival and can use end user terminal receive antenna patterns, which are reflective of actual interference conditions expected to be encountered during system operation.

VII. THE COMMISSION SHOULD CONSIDER CAREFULLY ITS PROPOSAL TO EXTEND ITS COMPLIANCE SHOWING FOR KU-BAND NGSO FSS SYSTEMS TO NGSO FSS SYSTEMS IN THE KA-BAND

As Boeing indicated in its initial comments,³⁰ Boeing does not object to the Commission's proposal to incorporate into its rules the EPFD limits that exist in Article 22 and Resolution 76 (Rev.WRC-15) for NGSO FSS systems operating in the Ka-band.³¹ Boeing continues to be concerned, however, about the Commission's proposal to import all of its

²⁸ See *SpaceX Comments* at 10, *OneWeb Comments* at 22, *SES/O3b Comments* at 19.

²⁹ See *Boeing Comments* at 8-9.

³⁰ See *id.* at 9.

³¹ See *NPRM*, ¶¶ 18-19; see also *SpaceX Comments* at 21-22, *OneWeb Comments* at 22-23, *SES/O3b Comments* at 19-20, *LeoSat Comments* at 10, *Kepler Comments* at 2, *Space Norway Comments* at 8 (each supporting the incorporation of the ITU's Article 22 limits for Ka-band NGSO FSS systems into the Commission's rules).

compliance measures for NGSO FSS systems operating in the Ku-band into its rules for NGSO FSS systems operating in the Ka-band.³² For example, as OneWeb observes, the Commission should reconsider its requirement that compliance with the ITU's operational and additional operational EPFD limits be demonstrated prior to commencing service.³³ The ITU originally adopted these requirements to give operators of GSO FSS networks a recourse to object if the operational limits are exceeded. The operational limits were not intended to serve as a gating criteria for new NGSO FSS system applicants and in no event should an operational compliance showing be required before an NGSO FSS system is brought into service. Thus, as OneWeb further explains "[i]f the Commission does not remove this requirement for all NGSO Ku-band operations, it should at a minimum not extend this obligation to NGSO Ka-band operations."³⁴

Aside from such relatively discrete and warranted adjustments to the Commission's compliance rules for NGSO/GSO spectrum sharing, however, Boeing continues to believe that it is not appropriate at this time to undertake a wholesale revision to the Article 22 limits for NGSO FSS systems either before the Commission or the ITU. Further, Boeing continues to question whether the compliance requirements that were adopted for NGSO FSS systems operating in the Ku-band are appropriate or necessary with respect to the Ka-band. The Ka-band involves a more recent allocation for the satellite industry with far fewer legacy users requiring significant regulatory measures to ensure their protection. Moreover, these newer satellites are equipped with more modern technologies that can be more resilient in their ability to share spectrum with other systems. Therefore, Boeing believes that the Commission should

³² See *id.*, ¶ 19.

³³ See *OneWeb Comments* at 26-27.

³⁴ See *OneWeb Comments* at 26.

proceed with caution in making a wholesale importation of its NGSO FSS rules from the Ku-band to the Ka-band.

VIII. THE COMMISSION SHOULD UPDATE ITS RULES FOR GSO/NGSO PRIORITY, BUT NOT BY GIVING GSO NETWORKS PRIORITY IN EVERY FUTURE FSS FREQUENCY BAND

All parties seem to agree with the Commission that it should eliminate Section 25.156(d)(5) of its rules, which effectively determines the priority of use of a new frequency band by deferring to the type of satellite system application that is filed first with the Commission.³⁵ The only major frequency band that would seem applicable to the existing rule is the V-band, where GSO, NGSO and hybrid-GSO/NGSO system applications have been filed over the years, but no commercial systems have yet been launched.

This said, Boeing continues to oppose incorporating ITU Radio Regulation No. 22.2 into the Commission's rules and thus requiring NGSO FSS systems to protect GSO FSS networks in all frequency bands unless explicit regulations are adopted to the contrary.³⁶ Such a default presumption would continue the legacy treatment of NGSO FSS systems as subordinate to GSO FSS networks when a far better view of the future involves a more reasonable regulatory balance between NGSO and GSO systems. Both types of networks will be needed by the satellite industry to provide the very high data rate broadband services that are required by consumers (both enterprise and individual) and therefore the Commission should not further entrench legacy regulatory presumptions to the contrary.

³⁵ See *SIA Comments* at 8, *Boeing Comments* at 11, *OneWeb Comments* at 24, *SES/O3b Comments* at 17, *Inmarsat Comments* at 9-10, *Space Norway Comments* at 9.

³⁶ See *Boeing Comments* at 11-12.

IX. THE COMMISSION SHOULD EXPAND AND CONTINUE TO ENFORCE ITS IN-LINE AVOIDANCE RULE

The vast majority of parties filing comments in this proceeding supported the extension of the Commission's in-line avoidance rule to additional frequency bands.³⁷ These parties appear to recognize that the in-line avoidance rule, while far from perfect, serves as a critical mechanism to force operators of competing NGSO FSS systems to the negotiating table in order to compel them to develop coordination measures acceptable to each party, or implement the in-line avoidance approach absent such agreement.³⁵

Only one party argued for the elimination of the Commission's in-line avoidance approach, arguing that the ITU's first-in-time coordination approach will create greater regulatory certainty for NGSO FSS systems.³⁸ Certainly, the ITU's approach – which has not yet been adopted for the V-band – would give regulatory certainty to the sole NGSO FSS system that holds priority in a particular frequency band. The ITU's approach, however, would provide no regulatory certainty for any other NGSO FSS systems except for the certainty that they will be fully subordinate to the first system.

In this regard, the ITU's first-in-time approach does not transition effectively from its use for GSO FSS networks (for which it was originally created) to NGSO FSS systems. The operator of a GSO FSS network has coordination priority only with respect to a few degrees of orbital resource along the GSO arc. In contrast, the operator of an NGSO FSS system could conceivably control the entire use of a particular frequency band by all other NGSO FSS systems everywhere in the world.

³⁷ See *Boeing Comments* at 12, *SpaceX Comments* at 16-17, *OneWeb Comments* at 12, *SES/O3b Comments* at 23, *LeoSat Comments* at 11, *Lockheed Comments* at 2.

³⁸ See *Telesat Comments* at 6-15.

In recognition of the risk of this disproportionate authority, the Commission sought to develop its own spectrum sharing rules to ensure that multiple NGSO FSS systems will be able to operate successfully in every frequency band. Certainly, the implementation and compliance with the Commission's in-line avoidance requirements will likely be difficult for all parties involved (further incentivizing them to develop their own coordination mechanisms), but the ultimate goal of ensuring that multiple competing NGSO FSS systems are able to operate in each frequency band on a shared basis is clearly worth the effort.

For this same reason, the Commission should reject LeoSat's proposal that the ITU's first-in-time approach be incorporated into the Commission's in-line avoidance approach in order to give the operator with ITU priority the discretion to use of the entire band during each in-line event.³⁹ Such an approach obviously would not encourage good faith negotiations toward spectrum sharing approaches that are reasonable and acceptable for all parties involved. The proposal of Space Norway to give preference to highly elliptical Orbit ("HEO") systems during in-line events would also provide no incentive on the part of such operators to negotiate equitable spectrum sharing arrangements.⁴⁰

Although nearly all parties expressed continued support for the Commission's in-line avoidance approach and its expansion for use in the Ka-band, there was significant disagreement on whether the Commission should retain 10 degrees as the appropriate criterion for defining an in-line event. OneWeb argued for the replacement of the 10-degree approach with a power

³⁹ See *LeoSat Comments* at 12.

⁴⁰ See *Space Norway Comments* at 9-12 (arguing that during an in-line event between a circular NGSO system and a HEO, the Commission should place the burden of avoiding interference on the circular NGSO system).

based criteria, such as the ITU approach of a $\Delta T/T$ of 6 percent.⁴¹ The Commission, however, carefully considered and rejected such a power based approach when it originally adopted its in-line avoidance requirements.⁴² OneWeb has not provided any basis for reconsidering that conclusion.

Other parties continue to support the 10 degree approach,⁴³ while some have suggested that it should be reduced to a narrower angle,⁴⁴ with one system applicant expressing support for an in-line avoidance angle of just 2 or 3 degrees.⁴⁵ Based on further review of the various NGSO satellite system designs that have been proposed for the Ka-band and V-band, Boeing has subsequently concluded that a 10 degree avoidance angle will likely continue to be necessary as a default requirement to ensure the protection of widely varying types of NGSO FSS systems. Obviously, individual NGSO FSS system operators may coordinate other avoidance angles or spectrum sharing approaches that work better for their proposed systems. The Commission encouraged such an approach in its 2002 ruling, and the current rules appropriately welcome such coordinated initiatives and should continue to do so.⁴⁶

⁴¹ See *OneWeb Comments* at 13-15.

⁴² The Commission considered and ultimately rejected the use of a 6% $\Delta T/T$ approach when it originally adopted its in-line avoidance rule in 2002, concluding that such an approach was primarily intended to address long term interference and may be inadequate to address short term interference. See *The Establishment of Policies and Service Rules for the Non-Geostationary Satellite Orbit, Fixed Satellite Service in the Ku-band, Report and Order*, 17 FCC Rcd 7841, ¶ 50 (2002) (“*NGSO FSS Sharing Order*”).

⁴³ See *SpaceX Comments* at 19-20.

⁴⁴ See *SES/O3b Comments* at 25, *LeoSat Comments* at 12, *Kepler Comments* at 4.

⁴⁵ *LeoSat Comments* at 12.

⁴⁶ See *NGSO FSS Sharing Order*, ¶ 48 (explaining that “[w]e believe that smaller angles of separation can be negotiated during coordination between the parties, and that the resultant increase in full-spectrum operation is an incentive toward reaching an agreement”).

The Commission should not, however, entertain ViaSat's argument that the in-line avoidance approach is fundamentally "inequitable" to certain types of NGSO systems such as the one proposed by ViaSat. ViaSat claims that during in-line events with Boeing's V-band NGSO FSS system, ViaSat may be unable to maintain uninterrupted ground coverage.⁴⁷ ViaSat, however, neglects to explain how such interruptions would occur given the fact that the Commission's in-line avoidance rule presumptively requires satellite operators to split the band in half during in-line events, thus maintaining ground coverage (albeit with less spectrum) by all satellites affected by an in-line event.

Further, the potential frequency of such in-line events is hardly unique to the ViaSat and Boeing systems, as both the OneWeb and SpaceX constellations and other LEO systems have proposed to operate in the Ka-band at lower altitudes than ViaSat's medium Earth orbit ("MEO") NGSO FSS system. In addition, subsequent to ViaSat's NPRM Comments, numerous additional applicants have requested authority to operate NGSO FSS systems in the V-band using LEO altitudes that are lower than the proposed ViaSat constellation. During each in-line event, the capacity of the two satellites affected by the event will each be cut in half. Thus, the detrimental impacts of in-line events will equally affect each party.

The options to address in-line events have long been discussed. When the Commission adopted its in-line avoidance approach in 2002, it specifically encouraged satellite operators to consider the potential benefits of satellite diversity to facilitate sharing. As the Commission explained:

With satellite diversity, NGO FSS systems can avoid an in-line interference event by selecting another visible satellite within their system constellation (performing a hand-over process) whenever the current satellite approaches the in-line event with a satellite

⁴⁷ See *ViaSat Comments* at 18-20.

operating in another NGSO FSS system constellation. Coordinating between themselves, NGSO FSS systems can employ satellite diversity in combination with other available interference mitigation techniques to avoid in-line interference events.⁴⁸

Given this history, SpaceX argues that the Commission should take additional steps to encourage NGSO FSS system operators to use satellite diversity to facilitate sharing.⁴⁹ For example, SpaceX suggests that “NGSO system with a high level of satellite diversity would be entitled to use more spectrum during in-line events than a system that has little or no overlap of satellite coverage areas.”⁵⁰

Boeing believes that both ViaSat and SpaceX’s proposals would involve the Commission excessively and inappropriately in the network design decisions of individual NGSO FSS system operators. The Commission’s rules should neither penalize nor reward NGSO FSS systems for their proposed coverage or satellite diversity capabilities. Instead, the Commission should retain its in-line avoidance rules with equal-band splitting during events, and continue to encourage NGSO FSS system licensees to coordinate between themselves to determine how they will accommodate in-line avoidance events within their system designs once multiple systems are operational.

At the same time, the Commission should eliminate the band segmentation procedures specified in Section 25.157(e) and refrain from extending the procedures to any additional frequency bands. As OneWeb explained, the adoption of a band segmentation approach for

⁴⁸ See *NGSO FSS Sharing Order*, ¶ 54.

⁴⁹ See *SpaceX Comments* at 27.

⁵⁰ *Id.*

additional NGSO FSS frequency bands “would further limit the ability of operators to deploy such systems in what already is a challenging spectrum environment.”⁵¹

X. THE COMMISSION SHOULD ALLOW NGSO FSS SYSTEM OPERATORS TO CHOOSE HOW THEY MAKE THEIR EPHEMERIS DATA AVAILABLE TO OTHER SYSTEMS

Surprisingly, one of the issues of greatest divergence among the parties that filed comments in response to the *NPRM* was the manner in which ephemeris data is made available to other satellite operators. Several commenters agree that it is sufficient to update ephemeris data every three days unless individual circumstances necessitate more frequent updates, such as the addition or removal of satellites, or with respect to satellites that lack station keeping capabilities.⁵²

The manner in which ephemeris data is shared with other operators, however, engendered a variety of different views. The predominant view – and the one that Boeing supports – is that satellite operators should be permitted to share such data using whatever means they choose, and not necessarily through the use of a website.⁵³ Thus, while many operators may choose to use a secure website for such purposes, as advocated by SES, O3b, and Lockheed,⁵⁴ others, such as OneWeb, may choose an alternative approach, such as through “traditional coordination channels.”⁵⁵

⁵¹ See *OneWeb Comments* at 12.

⁵² See *Boeing Comments* at 15, *Lockheed Comments* at 3-4, *Telesat Comments* at 17.

⁵³ See *Boeing Comments* at 15, *OneWeb Comments* at 15, *PlanetLabs/Spire Comments* at 4, *Kepler Comments* at 2.

⁵⁴ See *SES/O3b Comments* at 25, *Lockheed Comments* at 3.

⁵⁵ See *OneWeb Comments* at 15.

What is most evident in the comments is that no party has identified a compelling reason why the Commission should mandate a particular approach to sharing of ephemeris data. Although such sharing of data will clearly be necessary, there is no indication in the record that NGSO system operators may be inclined to withhold such data, or make it difficult for other NGSO system operators to access. Therefore, absent clear evidence to the contrary, the Commission should refrain from constraining operators by mandating that they use one particular means to share ephemeris data, such as through a single potentially-governmental source.⁵⁶

XI. THE COMMISSION SHOULD REFRAIN AT THIS TIME FROM MANDATING EARTH STATION TRANSMIT EIRP DENSITY LIMITS OR RECEIVE GAIN CAPABILITIES

Boeing concurs with other prospective operators of NGSO FSS systems in opposing the adoption of uplink off-axis EIRP density limits for earth stations operating with NGSO FSS systems.⁵⁷ Such restrictions if imposed at this time could impede the development of new types of NGSO systems and services, particularly services intended to serve populations that currently do not enjoy access to robust broadband communications services. As OneWeb explains, the adoption of uplink off-axis EIRP density limits may have been necessary for GSO FSS networks because the Commission mandated their compliance with a 2-degree spacing rule.⁵⁸ Comparable requirements do not exist for NGSO FSS systems.

⁵⁶ *Contra SpaceX Comments* at 19, *Telesat Comments* at 16, *LeoSat Comments* at 13-14 (suggesting the use of the Space Data Association or an ITU designee).

⁵⁷ *See Boeing Comments* at 15-16, *OneWeb Comments* at 27-28, *LeoSat Comments* at 14-15, *Telesat Comments* at 17.

⁵⁸ *See OneWeb Comments* at 28.

Some parties argue that uplink off-axis EIRP limits are needed for NGSO FSS systems in order to ensure that in-line interference events do not occur outside of the main-lobe of the transmitting earth station antenna.⁵⁹ Boeing believes, however, that NGSO FSS system operators already have sufficient incentive to limit the off-axis emissions from their earth stations in order to avoid intra-system interference into their own satellites. Further, the adoption of EPFD limits for NGSO to GSO sharing, along with retention of the in-line avoidance requirements, provide additional incentives to control and limit terminal off-axis performance. Thus, absent the actual identification of a problem in this regard, the Commission should refrain at this time from regulating the off-axis emissions from earth stations operating with NGSO FSS systems.

For substantially the same reason, Boeing also does not support the Commission's proposal to adopt NGSO system downlink power limits or Earth station gain criteria.⁶⁰ Operators of NGSO FSS systems already have adequate incentive to optimize such capabilities for their own purposes. Further, as O3b and SES explain, the adoption of such limits may be difficult to define for time-varying systems.⁶¹ The Commission should also refrain from adopting earth station receive gain criteria, which, as LeoSat explains, likely would restrict the types of antennas that may be selected for the provision of NGSO FSS services.⁶² As the Commission is aware, the ultimate cost of the satellite end user terminal has historically been one of the major factors in restraining the launch of additional NGSO FSS systems. The

⁵⁹ See, e.g., *SES/O3b Comments* at 27-28, *Space Norway Comments* at 13, *Lockheed Comments* at 4.

⁶⁰ See *NPRM*, ¶ 29.

⁶¹ See *SES/O3b Comments* at 28.

⁶² See *LeoSat Comments* at 14.

Commission should therefore avoid adopting requirements that may increase the costs of such terminals unnecessarily and instead permit the market (and innovation) to develop on its own.

XII. THE COMMISSION SHOULD REVISE ITS MILESTONE RULES TO REFLECT THE REALITIES OF VERY LARGE NGSO FSS SYSTEMS

Nearly all commenters expressed agreement with the Commission that substantial changes are needed in its milestone regulations for NGSO FSS satellite systems. The Commission's current requirement that NGSO FSS system operators launch all of their authorized satellites by the sixth-year milestone deadline is punitive and does not serve the underlying purpose of the Commission's milestone rules, which is to ensure that scarce spectrum and orbital resources are not left fallow.

Many parties acknowledged that, although an improvement, the Commission's proposal to require the launch of at least 75 percent of a constellation after six years is still far too restrictive.⁶³ The Commission should instead recognize that any fixed percentage requirement – including any of those proposed by other commenters in this proceeding⁶⁴ – inherently involves somewhat arbitrary line drawing that will force some operators to launch satellites before they are needed solely to meet the milestone. Instead, the Commission should adhere to its original public policy goal by ensuring that satellite licensees promptly and actively use their licensed spectrum and orbital assets. Further, the definition of such prompt and active use may be different for each proposed satellite system.

⁶³ See *Boeing Comments* at 17, *SpaceX Comments* at 13, *SES/O3b Comments* at 29-32, *Space Norway Comments* at 14, *PlanetLabs/Spire Comments* at 5-6, *Kepler Comments* at 5 (calling for much more flexibility for nano-sats).

⁶⁴ See *LeoSat Comments* at 15 (proposing 50% after six years); *SES/O3b Comments* at 32-33 (proposing 33% after six years); *Space Norway Comments* at 14 (proposing 10-20%).

This is why Boeing and other parties continue to support a plan to allow NGSO FSS satellite system applicants to identify in their applications the constellation size that constitutes the “initial deployment” of their systems.⁶⁵ Such initial deployments should be sufficient to provide adequate coverage to their entire initial service area, but perhaps not redundant or diverse coverage. As long as an applicant’s proposal is reasonable, it should be accepted by the Commission.

OneWeb, in contrast, opposes any changes to the Commission’s milestone requirements, arguing that providing additional flexibility may give licensees an incentive to request far more satellites than they realistically intend to launch.⁶⁶ Of course, licensees already often do request authority to launch more satellites than they ultimately operate (in part because of the risk of asking for too few in the face of an application cutoff deadline). As a result, satellite licensees occasionally use the Commission’s license modification process to later reduce the size of their constellation if necessary to reflect the actual demands of the market. OneWeb argues that such reductions in constellation size may result “in reduced service offerings and availability for those in rural and harder to reach locations.”⁶⁷ The alternative of forcing operators to launch satellites they do not need, however, would increase costs unnecessarily for such operators and heighten their potential for bankruptcy, which would have an even greater detrimental impact on the availability of broadband services in rural and hard to reach locations.

⁶⁵ See *Boeing Comments* at 18, *Telesat Comments* at 18, *SpaceX Comments* at 14-16 (suggesting a requirement of a new threshold at least every three years after the initial deployment), *PlanetLabs/Spire Comments* at 7 (suggesting a flexible process).

⁶⁶ See *OneWeb Comments* at 1-7.

⁶⁷ See *id.* at 6.

OneWeb further argues that introducing greater flexibility into the Commission's milestone rules would encourage speculation and force other operators to invest time and resources coordinating with speculative "'paper' constellations."⁶⁸ OneWeb seems to suggest that the only way to deter speculators adequately is to require the launch within six years of all satellites within a constellation. In contrast, Boeing believes that a more flexible obligation to launch a self-defined "initial deployment" of satellites within six years will still necessitate a large enough investment to adequately deter speculation. The initial deployment of even a modest-sized constellation will involve a tremendous investment in satellite and ground resources (vastly more than the Commission's bond requirement). Any licensee that successfully brings into operation its entire initial deployment of satellites could not reasonably be accused of warehousing spectrum or orbital resources. Therefore, the Commission should conclude that such an investment would be sufficient to dispel any suggestion of speculative intent.

ViaSat argues that allowing operators of large constellations to bring their satellites into service on a phased basis would make it more difficult for operators of other NGSO FSS systems to share spectrum and orbital resources with them apparently because they will have to accommodate and share spectrum with the new satellites as they are brought into service.⁶⁹ Of course, no NGSO system operator will bring all of its satellites into service at the same time. Due to the limits of the satellite manufacturing and commercial launch capacity, all operators will launch their satellites in multiple waves. Thus, the sharing environment between different NGSO FSS constellations will continually change as newer satellites are added to constellations and older ones are retired. Boeing (and other commenters) are simply advocating that the

⁶⁸ See *id.*

⁶⁹ See *ViaSat Comments* at 22.

deployment of large NGSO constellations be permitted to take place more gradually, thus giving competing NGSO system operators more time to plan for and adjust to the changes that will be necessary to enable such orbital and spectrum sharing possible. Therefore, the Commission should focus solely on its original goal of ensuring that spectrum and orbital resources do not lie fallow and refrain from forcing NGSO satellite system operators to deploy more satellites than they actually need to serve their initial customers.

XIII. THE COMMISSION SHOULD ELIMINATE ITS GLOBAL COVERAGE REQUIREMENT TO FACILITATE DIFFERENT BUSINESS APPROACHES

Nearly all parties support the Commission's proposal to eliminate its international geographic coverage requirement for NGSO FSS systems in order to afford system operators flexibility to design their constellations to maximize services to their intended customers.⁷⁰ SpaceX urges the Commission to continue one step further by eliminating its US domestic coverage requirement, particularly as it applies to coverage of Alaska.⁷¹

ViaSat concurs in its comments that eliminating the international coverage requirement would provide additional flexibility to NGSO FSS system operators.⁷² ViaSat opposes the proposal, however, apparently because ViaSat designed its system to provide full global coverage and apparently believes that it would be "fundamentally unfair" to refrain from requiring every other NGSO FSS system operator to do so as well.⁷³

⁷⁰ See *Boeing Comments* at 20-21, *SpaceX Comments* at 23-24, *OneWeb Comments* at 9, *SES/O3b Comments* at 35, *Kepler Comments* at 5, *Space Norway Comments* at 14-15, *Lockheed Comments* at 7.

⁷¹ See *SpaceX Comments* at 24-25.

⁷² See *ViaSat Comments* at 23.

⁷³ *Id.* at 24.

The Commission, however, should not continue to handicap an entire industry solely to assist ViaSat, particularly given the fact that ViaSat had every reason to anticipate that the Commission's international coverage requirement was likely to be eliminated (officially or informally) in the very near term. In 2015, the Commission waived its international coverage requirement for O3b without any party raising an objection to the waiver.⁷⁴ O3b's justification for seeking such a waiver was explicitly based on a business decision to optimize the focus of its network. As O3b explained, it designed its system "to focus bandwidth efficiently to areas where it is needed by the customer, rather than waste satellite power purporting to serve areas already adequately served or where there is no demand."⁷⁵

The following year, Boeing applied for Commission authority for its NGSO FSS system operating in the V-band. Based in part on the Commission's O3b precedent, Boeing also requested a waiver of the Commission's geographic coverage requirement. Although the Commission has not yet granted Boeing's request, Boeing's application was placed on public notice and no party raised any concern about Boeing's proposal to refrain from complying with the international geographic coverage requirement. Therefore, ViaSat has had ample indication that both the Commission and the satellite industry no longer see a significant need to retain this burdensome requirement and therefore it should be eliminated to maximize the efficiency and flexibility of NGSO FSS system operators.

⁷⁴ See Authorization of O3b Limited, IBFS File Nos. SAT-LOI-20141029-00118 and D-SAT-AMD-20150115-00004 (Call Sign S2935) (first issued Jan. 22, 2015).

⁷⁵ O3b Limited, Petition for a Declaratory Ruling Granting Access to the U.S. Market for the O3b MEO Satellite System, IBFS File Nos. SAT-LOI-20141029-00118 and D-SAT-AMD-20150115-00004, at 16 (Oct. 29, 2014).

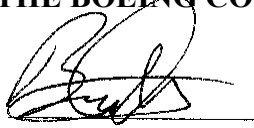
XIV. CONCLUSION

For the reasons discussed herein and in the comments of Boeing and other parties, the Commission should adopt measures that facilitate the deployment of additional NGSO FSS systems in order to provide very high data rate broadband services to all Americas and on a global basis.

Respectfully submitted,

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